Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE EFFECT OF THE ERUPTION OF KATMAI ON LAND VEGETATION

By ROBERT F. GRIGGS
Ohio State University

During the summer of 1913, while the writer was attached[1] to the kelp expedition sent by the Bureau of Soils, United States Department of Agriculture, to southwestern Alaska, he spent several weeks in the region devastated in 1912 by the eruption of Mount Katmai. He had frequent opportunities for short trips ashore and was able to observe the effect on the vegetation at numerous points.

The general features of the eruption and its effects on the country and on vegetation during the first few months have been excellently described by Martin[2], and Captain Perry[3] of the revenue cutter *Manning* has given an account of the conditions prevailing during the eruption, while Rigg[4] has described the effects on marine vegetation.

Our first experience with the ash was at Seldovia and Chinitna Bay (Fig. 1), where the fall was less than an inch. Here the ash was light gray or almost white, and consisted of very finely divided fragments, which covered the clothes and irritated the throat. On the lower slopes of St. Augustine Volcano the deposit was somewhat thicker and looked like a thin fall of snow, giving the already barren and desolate landscape an indescribably weird appearance.

Throughout the region of heavier fall, however, most of the deposit consists of much larger particles, and the material is better described as "sand" than as "ash." When it first fell it became soft like quicksand after every rain and slid like liquid mud off the hillsides and down the valleys, burying everything in its track (Fig. 4). Martin says that traveling over the ash at that time was like crossing a field of molten tar. Now, however, it is well compacted like a surf-pounded sand beach and forms an almost ideal walking surface, being smooth, hard, and at the same time springy and resilient like rubber. In most places it is so compact that even hobnailed boots leave scarce a track behind them. There is no more tendency, however, for the particles to become cemented together than in the sand on the beach.

Mixed with the coarse sand particles is considerable very fine dust. Whenever the wind is strong, after some days of dry weather, this dust is carried into the air and forms a luminescent haze, which becomes thicker as the wind rises, resembling fog, and in heavy gales becomes a disagreeable dust storm.

While the ash no longer slumps off the hillsides *en masse,* the ordinary processes of erosion, of course, continue. Mr. M. D. Snodgrass of the Experiment Station told me that, on a hill near the experimental farm at Kalsin Bay, erosion had carried off all but two inches of the deposit on the steep upper slopes, while on the summit the original eleven inches remained undisturbed, and on the flat below the thickness was greatly increased by wash from above.

---

[1] As scientist in kelp investigations.

[2] G. C. Martin: The Recent Eruption of Katmai Volcano in Alaska. *Nat. Geogr. Mag.*, Vol. 24, 1913, pp. 131-181.

[3] K. W. Perry: Volcanoes of Alaska. *Nat. Geogr. Mag.*, Vol. 23, 1912, pp. 824-831.

[4] Geo. B. Rigg: The Effects of the Katmai Eruption on Marine Vegetation. *Science*, N. S., Vol. 40, 1914, pp. 509-513.

Character of Former Vegetation. The impression of a stranger arriving at Kodiak, which is typical of the devastated area, is that the eruption has had little effect on the vegetation. The landscape so much resembles an ordinary sand-plain, with its scattered coniferous trees and open sand spaces, that it is difficult to persuade one's self that it was not always so (Figs. 3 and 5). However much I read the raptures of Burroughs[5] over the pastoral scenes of "Green Kodiak," it was impossible for me to form any satisfactory mental image of conditions before the eruption. The few photographs I was able to secure showing the vegetation before the eruption helped, but were inadequate. The difficulty is increased by the fact that the eruption covered the transitional zone between the coniferous forest and the grass-land of the Alaska peninsula. The vegetation on either side of the devastated area differs therefore from that which was destroyed. But from observations of the composition of the vegetation, both east and west of the ash-covered region, together with a study of the remnants of vegetation to be found around Kodiak, it was possible to get a fair idea of the character of the original plant covering.

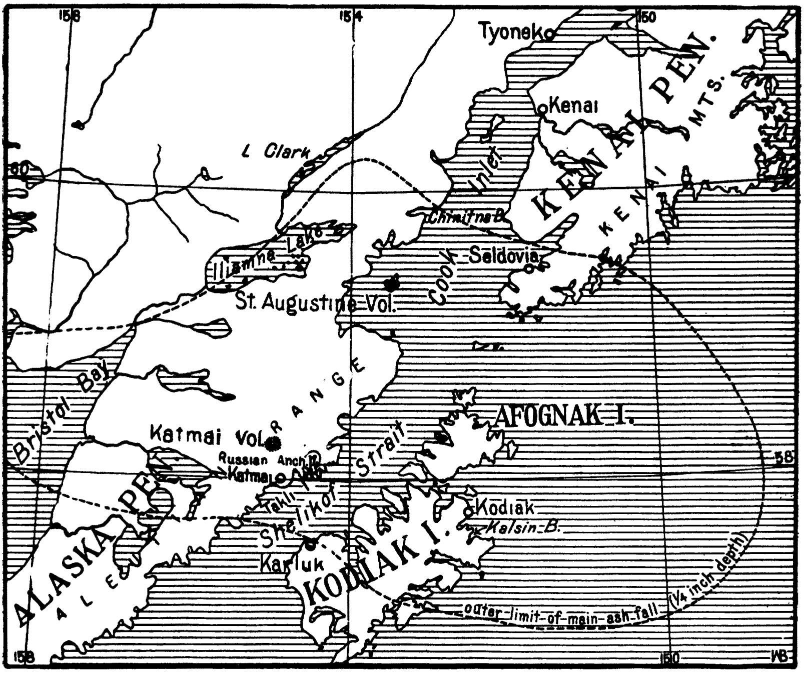

FIG. 1—Map of the region affected by the Katmai eruption, showing the outer limit of the main ash fall. Based on a map in the *National Geographic Magazine*, February, 1913. Scale, 1:5,800,000.

Around Kodiak the country was partly an extension of the spruce forest of the Sitkan region and partly open grass-land, with alder or willow and balsam poplar on the lowlands. In places where the spruces grew thickly the ground was occupied by the characteristic subordinate species of the Sitkan forest, including such plants as the devil's club*,[6] green hellebore* (Fig. 7), salmon berry,* ladyfern, beech-fern, and club-mosses. The numerous boggy or semi-boggy places were occupied by crowberry, mountain-cranberry, the northern bunchberry, an iris, the baked-apple berry, cotton-top grass, tall white bog orchis, the bog-cinquefoil, buckbean, marsh marigold, and bluebells, the last two reaching their best development only in swampy as contrasted with boggy places. The numerous ponds were full of the yellow flowers of the spatterdock* (Fig. 5).

---

[5] John Burroughs: Harriman Alaska Expedition. Vol. 1, p. 79.

In places where the spruces were more scattered the ground was occupied by breast-high blue-top grass with clumps of alder. Where conditions were favorable to blue-top it crowded out everything else and grew in pure stands. But where it was not so thick, low willows and a variety of herbaceous plants, many of them with showy flowers, came in, forming a mixed meadow in which wild geranium (Fig. 7), fireweed,* painted cup, lupines (Fig. 6), cow parsnip,* bluebells, arctic star-flower, monkshood, and lady-fern were prominent.

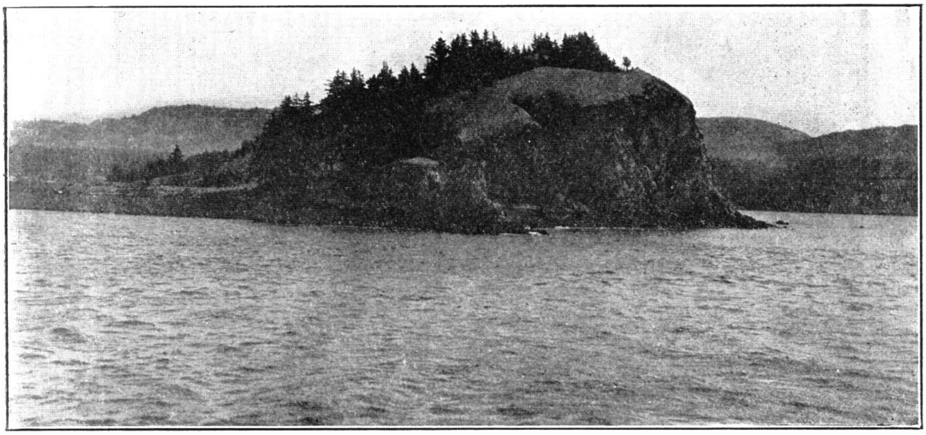

Photo by J. E. Thwaites.

FIG. 2—A blanket of volcanic ash among the spruces destroying the humbler plants. Ouzinkie, near Kodiak.

Grass-land of this type is common on the less fertile lands to the westward (the richer are occupied by the red-top and alder).

Destruction of Vegetation around Kodiak. The effect of the fall of ash was to annihilate all of the humbler plants except such as were favored by some special circumstance. Nothing could be more striking than a comparison of such a grass-land as that just described, with the hillside photographed on Near Island opposite Kodiak (Fig. 8), which before the eruption was covered with similar vegetation. Aside from the willows which protrude through the deposit no plant of any kind appears.

The plants formerly occupying this habitat were not, however, poisoned or

---

[6] Plants observed as survivals in the thick undisturbed deposits at Kodiak are marked with an asterisk.

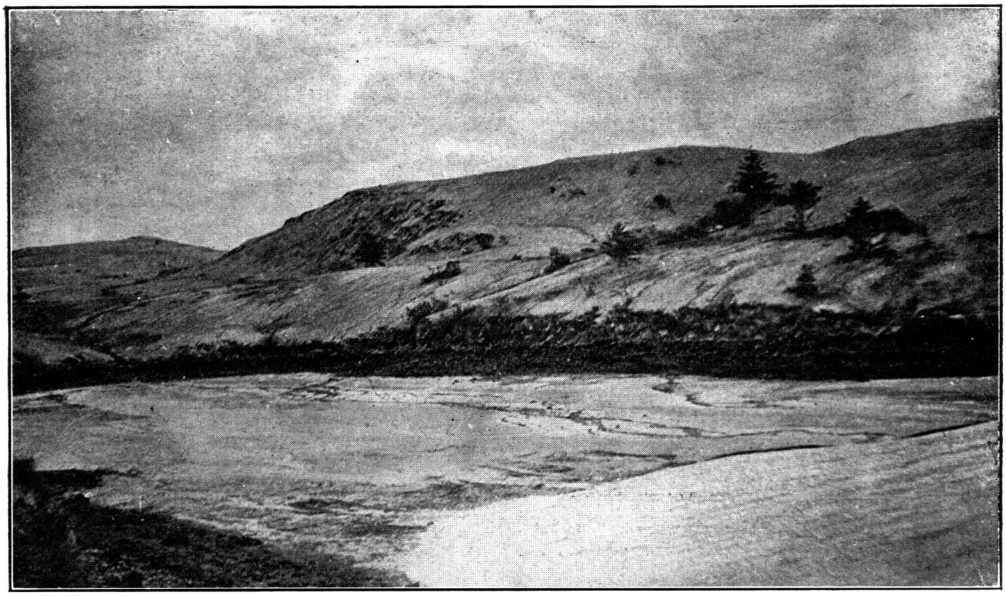

FIG. 3—A gently sloping hillside on Near Island, Kodiak. Contrast with the effect on steeper slopes shown in Fig. 4. Looking across a cove at extreme low tide. The waves keep the rocks between the ordinary tides clean but the flats below are deeply covered, with the consequent destruction of the seaweeds that formerly occupied them.

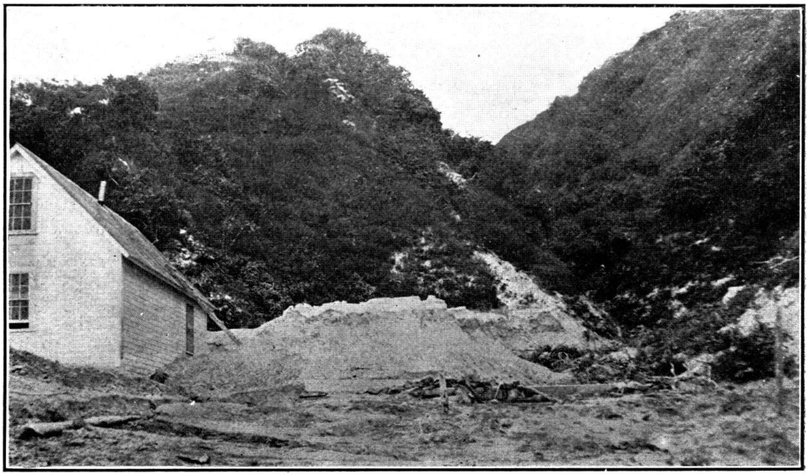

FIG. 4—Remnant of an "alluvial fan" washed out of a ravine. The ash came down as liquid mud and filled the houses full to the eaves. So much ash has slumped off the steepest hillsides that the vegetation (red top and alder) was comparatively little injured.

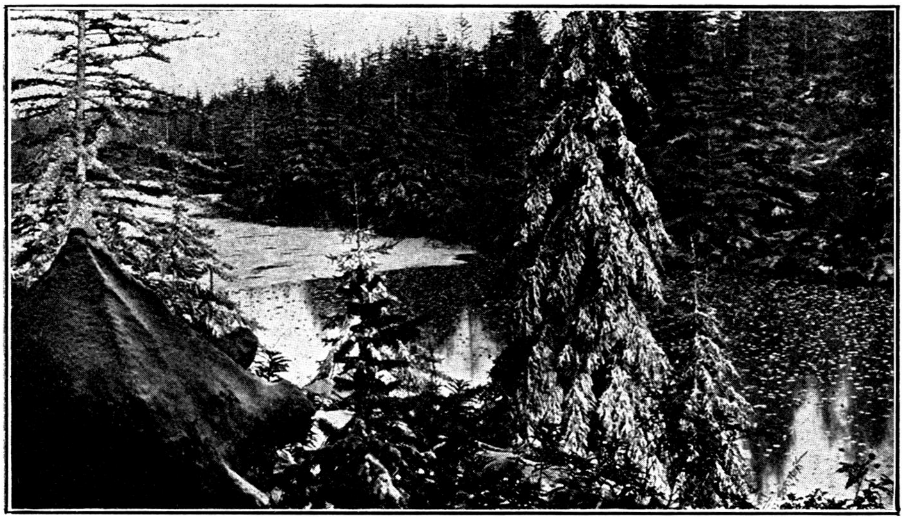

Photo by J. E. Thwaites.

FIG. 5—An ash landscape near Kodiak. Pond filled up and spruces covered. The plants coming through are largely fireweeds.

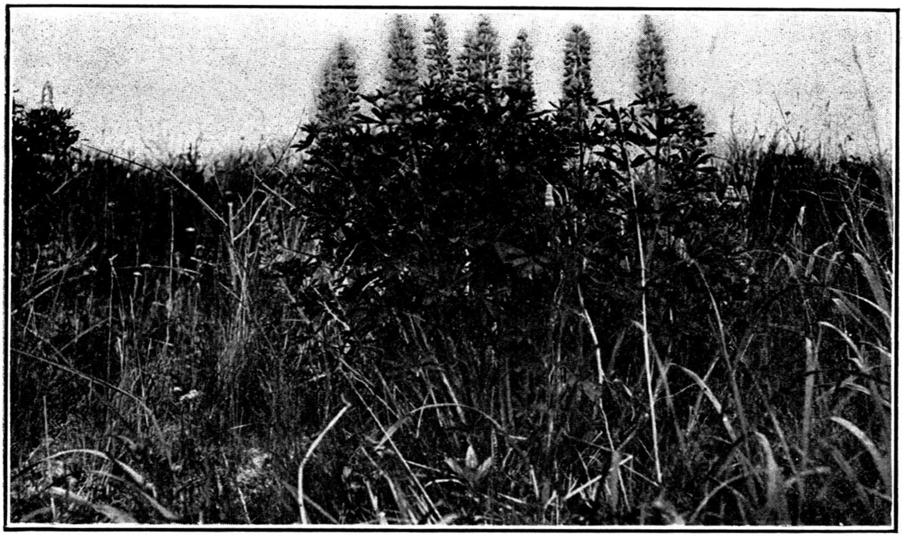

FIG. 6—Lupines. These and other strong-stemmed plants came up through the ash with undiminished vigor.

otherwise injured beyond the merely mechanical effect of the deposit. They were simply buried so deeply that they were unable to send new shoots through the ashy covering. Wherever there were plants capable of piercing the ashy covering, these survived. Mr. Snodgrass told me that the fire-weed, *Chamaenerium angustifolium,* was the salvation of the sheep after the eruption. Its strong, vigorous shoots came up through the ash where the more delicate culms of the red-top were destroyed. For the same reason the beach-grass, *Elymus arenarius,* was but little affected by the ash, and has come up everywhere almost in its original luxuriance. Plants of all sorts came up through the mud cracks which formed when the wet ash dried out Similarly, wherever the deposits slid off the hillsides so as to leave them bare or only thinly covered, the plants suffered comparatively little, and in the course of a few years will probably have recovered completely from the effects of the eruption (Fig. 4).

An interesting case of the survival of the fittest, under the new conditions, is the present abundance of the common horsetail, *Equisetum arvense,* which comes up freely through the ash where nothing else can. It displays the most curious reaction to the ash, also, in that oftentimes it does not grow straight up out of it, in its familiar switch-like form, but its main axis is suppressed at the surface and the lateral shoots spread out over the ground, forming tufts, or even mats, so that it looks like quite a different species. In places it forms a greensward of very attractive appearance. It is the abundance of such plants as this horsetail that gives the pseudo-natural appearance to the ash landscapes. One might easily believe that it was a natural sand-plain where horsetails had always flourished. According to Mr. Snodgrass, however, the horsetail was so scarce before the eruption that the natives did not know it and insisted until he dug down and showed them the old rootstocks beneath the deposit that it was a new plant which ''had come with the ash,'' which is their explanation for everything unusual.

While great quantities of ash must have blown off and washed off the spruces, the lower branches of some of them are laden almost as heavily as ever (cf. Figs. 5 and 10). The weight of these deposits bent down the limbs, which were previously horizontal or slightly ascending. This effect is very striking when comparison is made between pictures of the same situation before and after the eruption. The boughs are, moreover, very slow in resuming their original position even when completely free of ash (cf. upper limbs in Fig. 10). The presence of such incrustations must have injured them by smothering the leaves, but I did not notice any indication of blighting or similar injury, such as Martin reported after the eruption of Iliamna and predicted in the present case. The only indication of poisoning or other injury, beyond the merely mechanical effects of the ash observed near Kodiak, was in the death of most of the conspicuous beard lichens which were hanging blackened and dead from their places in the trees.

Alders Killed by the Fumes. Nearer the volcano, however, there were numerous indications of other destructive agencies besides the ash fall. Our only landing on the mainland was at Russian Anchorage near Takli Bay. As we approached the harbor we observed that all of the alder, which is the only sizable bush in this region, appeared killed off on slopes exposed toward the volcano, while on the opposite slopes, which were somewhat protected, they were green and luxuriant.

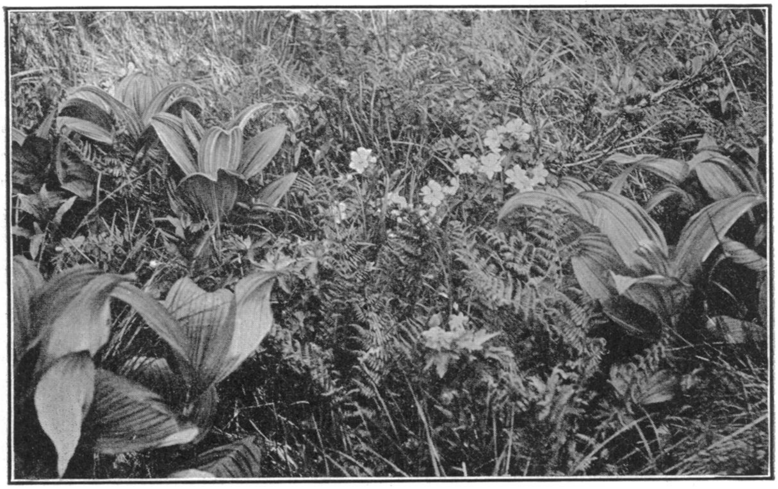

Fig. 7—Geraniums, hellebores, ferns and willows in the mixed meadow characteristic of the Kodiak district before the eruption.

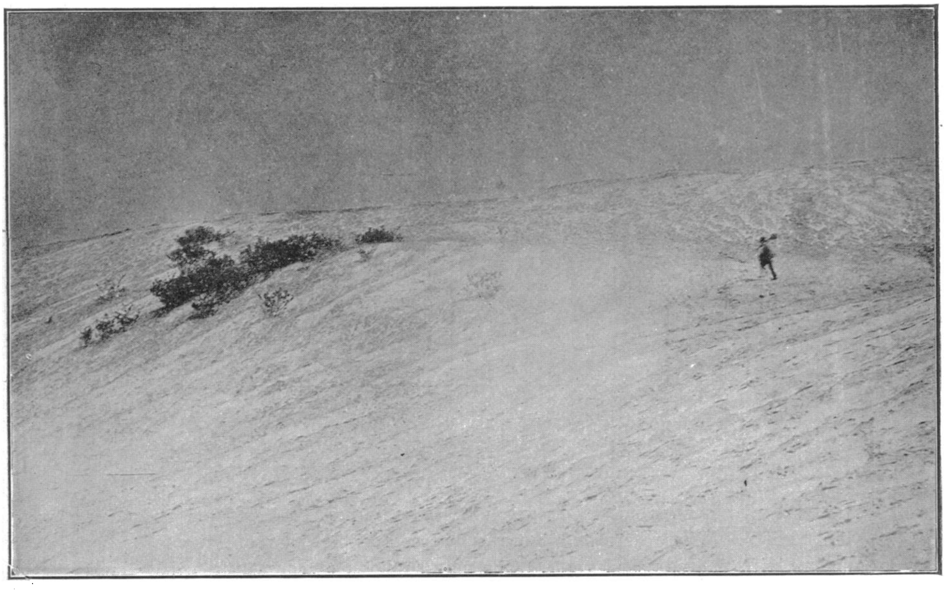

Fig. 8—A hillside where all vegetation except a few scrub willows was destroyed. Originally covered with a variety of herbaceous plants. Near Kodiak.

On examining the blighted bushes more closely, however, we saw that many of them were sending up new shoots from the roots, while on others new twigs were being put out here and there, giving the plants a very peculiar appearance, which at once aroused inquiry as to its cause. When the twigs of plants even apparently quite dead were broken it was found that they were still flexible and the cambium was still green as in any twig during the winter. The *buds,* however, were all shriveled and dead. It was evident, therefore, that the plants were not killed outright but were merely defoliated and their buds killed. Where here and there a bud escaped it grew out the following spring with undiminished vigor. One may suppose, of course, that these buds were killed by fumes or a hot blast from the volcano. This view receives apparent confirmation from the fact that such injury was confined to the exposed slopes in the station studied. It should be pointed out, however, that the erup-

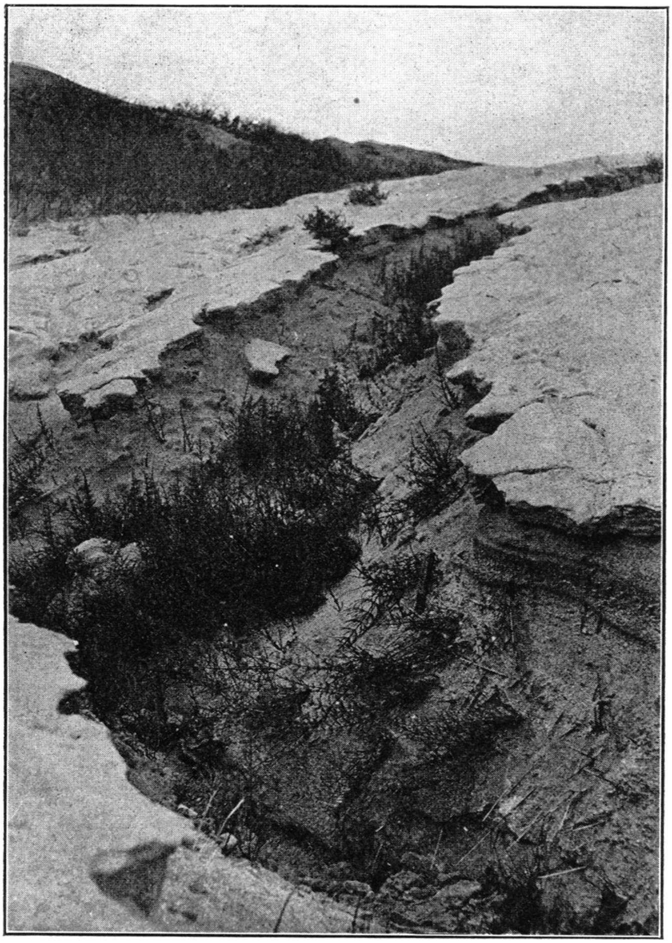

FIG. 9—Horsetails coming up in a gully where the general deposit was so deep that nothing could penetrate it. Russian Anchorage near Takli Bay on the mainland.

tion occurred on June 6, when the leaves had just expanded and both they and the buds in their axils were in an extremely delicate condition and unable to resist unfavorable conditions. Their death, therefore, does not argue as much for the strength of the fumes as it would have done had the same effect been produced by an eruption two months later.

The alder leaves of 1913 were almost all in good condition, but numerous leaves of the elderberry and devil's club were blighted, as though from fumes of an eruption, the summer of that year.

In this station the deposit was evidently much thicker (36 inches, according to Martin's map) than at any other station visited. On the steepest slopes, where the ash had been washed off, the vegetation was coming up with undiminished vigor, as at Kodiak; but on the flats nothing was coming through except in the gullies cut partly through the deposit. In these we found a vigorous growth of horsetails just as at Kodiak (Fig. 5).

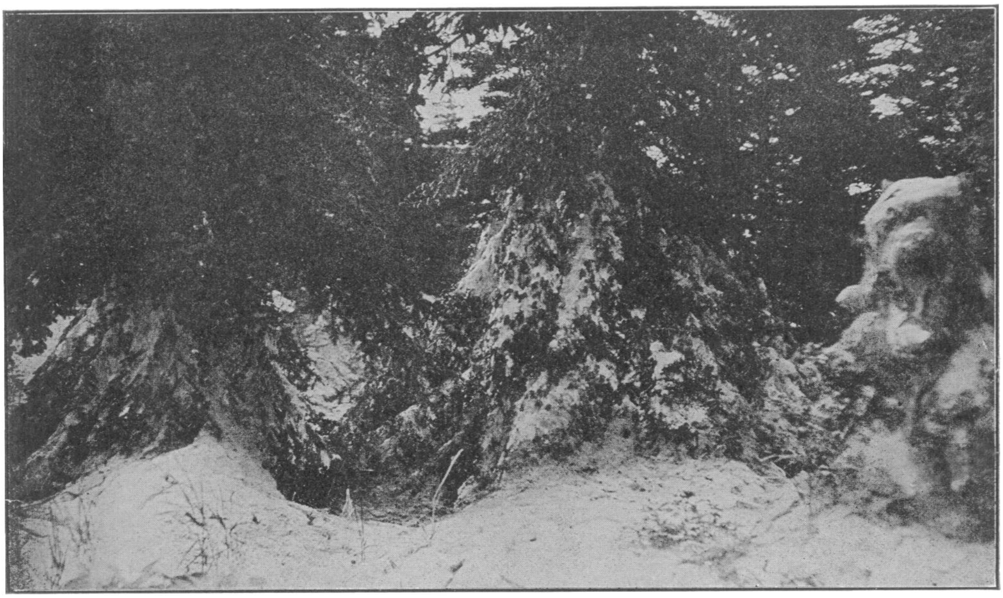

FIG. 10.—Ash clinging to the spruces after a year's rains. The upper branches, although completely free of ash, have not recovered their original horizontal positions.

Prospects of Re-vegetation. The present vegetation of the devastated area is composed entirely of the remnants of the original vegetation, either woody plants, which stick up through the ash, or shoots from old roots, which have penetrated it from below. While these are perennial and will grow and spread for several years, it remains to be seen whether the ash offers a substratum in which seedlings of the next generation can gain a foothold and spread over unoccupied territory.

When the ash is thin enough to be penetrated by a subsoil plow, so that the original soil can be mixed with the new material, there is reason to expect an increase in the agricultural value of the land, which before had a superabundance of organic matter and in many places was mossy and sour. In places more deeply covered, where the ash only is turned over by the plow, the outcome is more doubtful.

Despite its light, sandy character, the physical condition of the ash resembles that of a first-class soil. It is, of course, necessarily poor in the salts required by plants, but the analyses show a small amount of phosphoric acid and an amount of water-soluble potassium equivalent to the figures given in the text-books on soils as the minimum requirement of plants. Although this might not appear to augur well for the vegetation, a comparison of such analyses with that of the ash of Krakatoa, which, according to Ernst[7], had no phosphoric acid and only a trace of soluble potash, is all in favor of Katmai. Yet in the course of twenty-five years Krakatoa was occupied by a new vegetation, in places approaching the original in luxuriance. At the time of our visit Mr. Snodgrass of the Experiment Station and Mr. Learn of the Kodiak Baptist Orphanage were very much concerned in the attempt to grow forage for their stock on the ash. Although they modified the natural conditions by the addition of nitrogenous fertilizers, the marked success which is reported to have rewarded their efforts holds much of interest to botanists as well as to agriculturalists.

In the case of Krakatoa, higher plants apparently did not succeed at the beginning. The first vegetation to appear was a layer of blue-green algæ, *Cyanophyceae,* which covered the surface of the ash and pumice and prepared the way for the development of ferns which, perhaps largely on account of their wind-borne spores, were the first vascular plants to appear, while the grasses and other seed plants came in later still. Climatic conditions in Alaska are, of course, so different from those surrounding Krakatoa that the process of re-vegetation must necessarily follow a different course. At the time of our visit there was no indication of such a development of blue-green algæ as occurred at Krakatoa.

The soil would appear rather to be especially suitable for plants of dry-sand barrens; but there were no such sand barrens in the devastated region before the eruption and no arenicolous plants except the halophytes on the beaches. There are, therefore, no plants on the ground especially adapted to the new conditions, and in view of the remoteness of the country and its very limited commercial relations with the outside world it is apparent that there is small chance of their importation. It will be interesting, therefore, to see which of the native species succeed in occupying the new habitat and to observe the stages in the renewal of the plant covering. One would expect that the remnants of the original vegetation sticking through the sand would become the centers of growth from which the new vegetation will be established. If this should occur, there would arise from these survivals (or a part of them) a new type of association different from any formerly present in the region—an open association lacking the various humbler guilds of plants which originally carpeted the ground. If such an association should be formed, it would be interesting to observe whether it is relatively permanent or merely a transitory stage in the rehabilitation of the old order of things; that is, whether the small humicolous species can come in on the ash or whether they must await the slow development of a layer of humus from the remains of other species which can grow in the ash as it is. The very uniform development of bog, moor, and tundra (to which formations most of the exterminated species belong) over wide areas of diverse geological structure throughout this northern country would appear to indicate that these formations are favored by climatic influences, and if so it would appear safe to predict their early reappearance in the ash-covered country.

---

[7] A. Ernst: The New Flora of the Volcanic Island of Krakatau, p. 50. Cambridge, 1908.

Summary. The primary effect of the eruption, except in the immediate vicinity of the volcano, where the vegetation was killed, can thus be largely summed up by the one word burial; and the effect on the vegetation was pretty much proportional to the depth of the deposit. More interesting from the botanical point of view, however, will be the secondary effects, which will become manifest only gradually through the years in the adjustment of the vegetation to the new conditions occasioned by the fundamental change in the character of the habitats occupied by species relatively but little affected by mere burial and the destruction of the smaller plants.